

Session: EL+NS- TuA7	Quantitative Analysis of Charge Injection and Discharging of Si Nanocrystals and Arrays by Electrostatic Force Microscopy	Abstract # 1429
---	--	----------------------------------

Author(s)

L.D. Bell; Jet Propulsion Laboratory, Caltech
E. Boer; Caltech
M. Ostraat; Caltech
M.L. Brongersma; Caltech
R.C. Flagan; Caltech
H.A. Atwater; Caltech

Presenter
X

Correspond
X

Abstract:

Charge injection and storage in dense arrays of silicon nanocrystals in SiO₂ is a critical aspect of the performance of potential nanocrystal flash memory structures. We have performed charging experiments on Si nanocrystals both embedded within and deposited on SiO₂ using conducting-tip atomic force microscopy (AFM). In the case of both isolated aerosol-deposited nanocrystals and those formed by ion implantation and annealing of SiO₂ films, charging has been accomplished by moving a conducting AFM tip close enough to the nanocrystal to transfer charge. This charging and subsequent discharging were characterized by monitoring the apparent change in nanocrystal height detected by AFM. The trapped charge produces an electrostatic force component that changes the response of the AFM tip, causing a change in the apparent height of the nanocrystal. This mode of electrostatic force microscopy (EFM) together with electrostatic modeling enables quantitative measurement of the trapped charge and discharging dynamics. Simulation enables the EFM sensitivity to be estimated systematically as functions of tip radius and height. Forces due to interaction with this charge and the induced charge on the tip can be determined, and AFM response to these forces can be calculated. Constant-force-gradient contours have been calculated that agree well with measured profiles, and we can determine the amount and location of the injected charge as well as some details of the discharge mechanism. Trapped charge as small 7e is detected in isolated small nanocrystals, and charge in the range 100e - 1000e is observed in larger isolated nanocrystals or embedded nanocrystal ensembles. The combination of EFM imaging and simulations can be used to estimate the homogeneity of the charge density and to probe for high conductance paths within a nanocrystal floating gate. Modeling indicates a discharge mechanism consistent with tunneling through a field-lowered barrier.

Note: Requested an Oral Session.